NOTES ON SERIES STREET INCANDESCENT LIGHTING

Being a Reprint of the Paper Read by Mr. Welles E. Holmes before the New England Association of Electric Lighting Engineers, March 18, 1903

February, 1904 *No. 9130*

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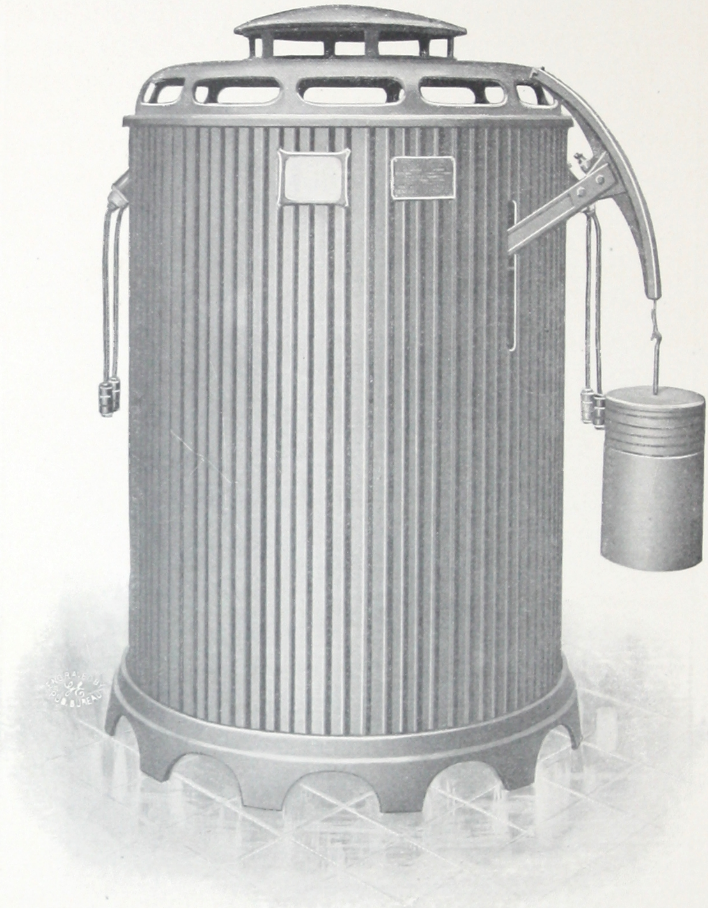


1.75
3.

CONSTANT CURRENT TRANSFORMER, AIR COOLED—35 KW.

INTRODUCTORY

In the following paper is described an installation controlled by General Electric constant current reactive coils. Since this installation was made the constant current transformer has been adopted by the General Electric Company as the standard regulator for incandescent lighting, the reasons for this step being as follows:

If reactive coils are connected directly to the primary feeders the initial cost in some cases may be lower than the cost of a constant current transformer, but a ground on the lamp circuit will ground the entire generating system. Two such grounds are liable to cause a short circuit on the generator. Moreover, with the reactive coil system the natural tendency is to use high current, low voltage lamps, in order to get as many lamps as possible in series on a given voltage.

By the use of the constant current transformer, which is usually built to step-up the voltage, low current high voltage lamps may be used. These lamps have much lower cost, and, therefore, the yearly cost of operation is reduced by their use. As an instance, it may be mentioned that by the use of 1.75 ampere lamps, as compared with 3.5 ampere lamps, a saving of nearly 50% in the cost of lamp renewals is secured. The importance of this will be readily appreciated by central station managers.

If the reactive coil is connected through an insulating transformer the system will possess many of the advantages of the constant current transformer, but the initial cost of the combination will usually be higher.

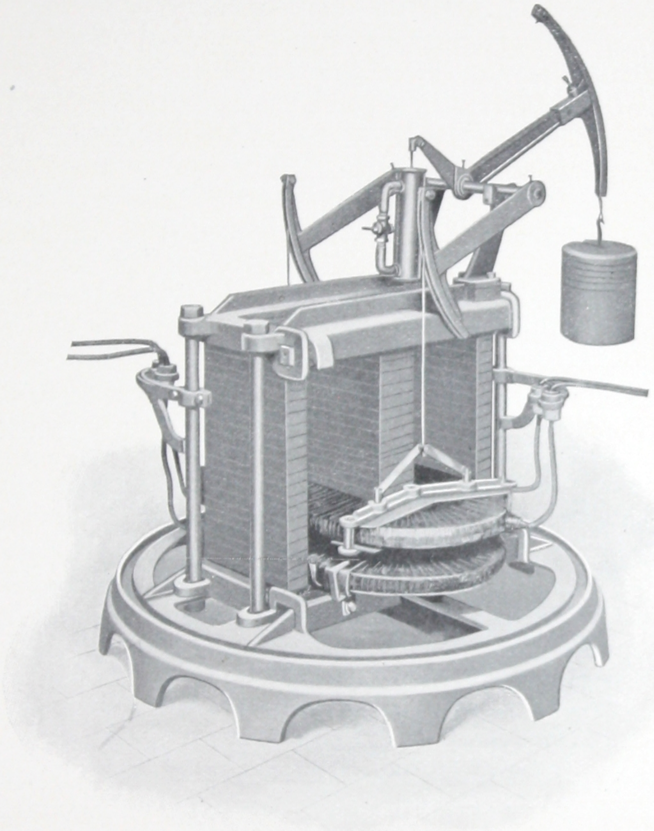
The constant current transformers used for this work are similar in construction to the transformers which are so well known in connection with series arc lighting. There is, however, one important difference.

The arc lighting transformers are designed for regulation to 1/3 inductive load and will regulate to 1/2 non-inductive load, while the transformers for incandescent lighting are all designed for regulation to no load and will maintain constant current through this range with great accuracy. This is an important consideration in incandescent lighting, since, if the transformers give only partial regulation, two grounds may occur, cutting out a large number of the lamps, causing the current to rise on the lamps remaining in circuit and seriously damaging them. This is of much greater importance in the case of incandescent lighting than in the case of arc lighting. For instance, an increase of 3% in current will not injure an arc lamp; but, if kept up continuously, will reduce the life of an incandescent lamp 42%. It is, therefore, imperative that the regulator on a series incandescent system maintain the current constant under all conditions.

A complete line of 60 cycle transformers has been developed in the sizes shown on page 15. These transformers may be used on 125 or 133 cycles with slightly reduced output. The General Electric Company has also developed a line of switchboards for the control of 1, 2 or 3 of these transformers, these panels being furnished with wattmeters mounted on sub-base where desired.

A complete system includes constant current transformer, panel, lightning arresters, brackets (including shades and deflectors,) porcelain sockets, and lamps.

More detailed information regarding this system may be found in Bulletin No. 4364 which has just been issued.



35 KW AIR COOLED CONSTANT CURRENT TRANSFORMER
WITH CASING REMOVED

NOTES ON SERIES STREET INCANDESCENT LIGHTING

By WELLES E. HOLMES

In speaking on this subject I shall not attempt to present to you all the known systems and devices for operating series incandescent lamps, but shall confine myself to a short talk on the changes and developments in this art covering a period of seventeen years.

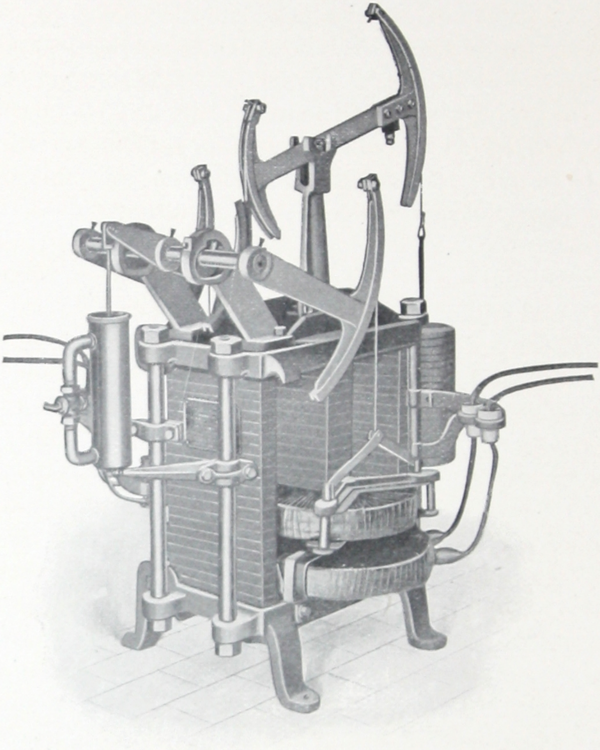
Probably the first attempts at series incandescent lighting came with the advent of the series arc machine, and many of you here today have operated incandescent lamps in series with your arc lamps and are perfectly familiar with the method employed. This means of lighting required the series socket and film cut-out substantially as they are used today, and, on account of the automatic regulation of the arc generator in keeping the current constant, the lamps had a fair average life.

The troubles were mostly with the socket, open circuits being of frequent occurrence, due to the burning of contacts and broken lamps. The outage deducted by the City for a 50 light arc circuit being out was much in excess of what it would have been had the whole circuit been of incandescent lamps alone.

During the latter part of 1885 and the first part of 1886 the alternating current generator first came to the notice of the central station man as a means of doing what was then considered as long distance multiple incandescent lighting by transformers. The writer at this time was associated with the first Newton station, of which Mr. H. H. Cutler, now of the Cutler-Hammer Co., was superintendent. At this time we had one of the first alternating current generators, a 400 light affair of 1000 volts, and no system of series lighting from this alternating current generator had then been devised by

anyone. Mr. Cutler took this matter up and built, patented and perfected a series socket applicable to the needs. He also built the first circuit of series incandescent lamps operated from an alternating current generator. This was done in the streets of Watertown, Mass. Among those who came to see this novelty at that time were George Davenport, Samuel Peck, George Curtis, A. L. Rohrer and Prof. Thomson. From this beginning the Thomson-Houston Company took hold of the system, acquiring the Cutler socket patent, and placed it on the market. The necessity of some means of hand or automatic regulation was at once apparent to the users of this system to prevent the increase in the current strength when lamps were burned out or broken. Cutler partially accomplished this by means of a double socket holding two lamps. Thus the front lamp burned under normal conditions; but when, in case of the failure of the front lamp to burn from either burn-out or breakage, the back lamp would start up automatically by reason of the operation of the film cut-out.

At the same time the Thomson-Houston Co. brought out the Bank Board system of regulation which consisted of a suitably mounted ammeter in the circuit with the series street lamps; series lamps mounted on the bank board and a switching device for cutting in or out of the circuit these additional lamps. By this means the station attendant could, when he saw by the ammeter that the current strength increased, cut additional lamps into the circuit, thereby restoring the current to normal. Many times has an operator of this system, having during the night cut into the circuit his five extra lamps, had to cut the whole circuit out in order to save it from burning up, it being better to stand the outage deducted by the City or Town than to lose



8.8 KW. CONSTANT CURRENT TRANSFORMER
WITHOUT CASING

the 40 series lamps. One of the great faults of this system at this time was the necessity of installing a definite number of lamps on the circuit, such as ten 100 volt lamps, twenty 50 volt lamps or forty 25 volt lamps and no more or no less, and in case such circuit was shy, say two lamps, by reason of the city not ordering them

in that locality, we had to burn these two lamps on the bank board or in a box on a pole outside until such time as the City should order a new lamp placed. In case a circuit already had its full complement of lamps and two or three more had to be placed, it became necessary to cut over the circuit with some lightly loaded circuit in order to remove two or three lamps from the already loaded circuit to the lightly loaded circuit; this meant very often a great expense for installing two or three lights.

About 1890 we were given the Thomson Reactive Coil, or Dimmer, as some called it. This coil was what its name implies, a reactive device designed to be hand operated and placed in series of the street lamps to reduce the voltage. This coil was built to reduce from 1000 volts to 750 volts or a kick of 250 volts. This meant ten 25 volt lamps and allowed us to build a circuit of thirty lamps. Then by means of this coil we could keep adding a lamp at a time at a small expense, as the City ordered, up to the full number of 40 lamps, when the coil could be removed for use on some new circuit.

At the same time there was no certainty even with this coil in use that the circuit would not burn up on an increase in the current strength caused by the burning out or breakage of several lamps, as the coil would not automatically care for such increase.

During the years covered by the foregoing it was evident to the central station man that what he needed to make this system of series incandescent lighting a success was some device whereby the current strength should be maintained constant regardless of the change of lamp load on the circuit.

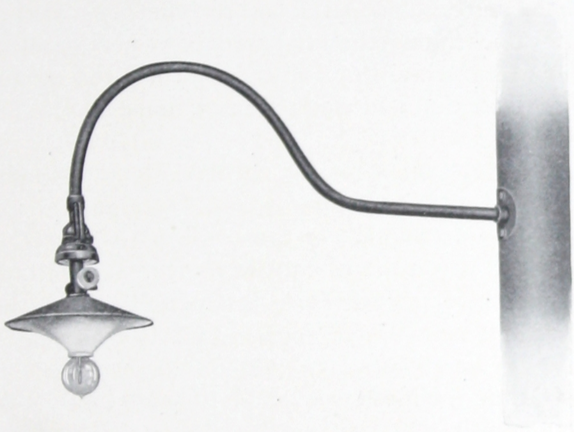
One of the first devices for accomplishing this was the Westinghouse Shunt Box System.

This system consists of a small choke coil placed in multiple with lamp; also a common multiple socket and 25 candle power lamp.

Ten of these 100 volt coils and lamps are placed in series on 1000 volt mains or twenty 50 volt coils and lamps on 1000 volt mains. The operation is substantially as follows: Taking, for instance, the 100 volt, 60 cycle coil and lamp; when all the ten lamps are burning very little current passes through the coil. It was found by actual test that the coils took about 4.5 watts, the lamp taking about 90 watts, making the total amount of energy taken per unit of installation 94.5 watts, and when the circuit is full the efficiency and power factor under the same conditions equal about 95%. But on the other hand the amount of energy taken for regulation is 4.5 watts per lamp and on a 125 lamp circuit would amount to 562 watts. This same number of lamps on a reactive coil system would require but 130 watts for regulation, making a saving of 432 watts per circuit in favor of the reactive coil system. The cost of coils for 125 light circuits would be about $475, while for a reactive coil to do the same business, would be about $140. The socket and lamp in the Westinghouse Shunt Box System have an advantage over the Series System, the Westinghouse Shunt Box System costing 45 cents per socket and the lamp and series system $1.15 per lamp and socket, but this advantage does not outweigh the first consideration mentioned. One of the principle characteristics of this system was that on a lamp burning out, the coil then came into the circuit, taking the place of the burned-out lamp; but under actual working conditions this coil does not prevent a rise of current as the lamps burn out, the rise amounting from 8 to 10% before the current will begin to return to normal. So there is no such thing as constant current from this system.

Next after this Westinghouse Shunt Box System came the CR Regulator of the General Electric Company.

But before speaking of the CR Regulator, I want to say that we had in use at Newton a static transformer with taps brought out from the secondary winding and so arranged in the circuit that its secondary voltage could be added to or subtracted from the circuit voltage.



SERIES INCANDESCENT LAMP BRACKET

This device had a range of eleven lamps either way from forty, was very efficient and saved us considerable expense by allowing us to add or take away lamps from the circuits without cutting over to balance up. It was, however, hand regulated and did not prevent our old trouble of burning up the circuit.

This CR Regulator was a compensator with secondary taps brought out and means whereby an operator could change by hand the effective voltage at the terminal

of the circuit. This device had a high power factor and high efficiency, but lacked auto-regulation.

The next step brings us to the automatic regulators, a number of which devices were placed on the market at about the same time for attaining constant current regulation, and we note that they are of two distinct types, the repulsion type, as shown in the General Electric Company's make, and the attraction type, as shown in the Helios-Upton Company, Manhattan, and the General Incandescent Arc Light Company's makes.

It came time for us to choose which of these types we should adopt and then which make we should adopt, and, after carefully testing all these above mentioned, it became evident to us that the repulsion type was better than the attraction type, but in order to arrive at this conclusion we had to give careful consideration to the mechanical construction of the coils, as that has an important bearing on the life of the device.

The following electrical data were taken during tests:

Minimum impedance found to vary from 211 to 500 volts.

Maximum impedance found to vary from 1900 to 2130 volts.

Copper losses found to vary from 83 to 175 watts.

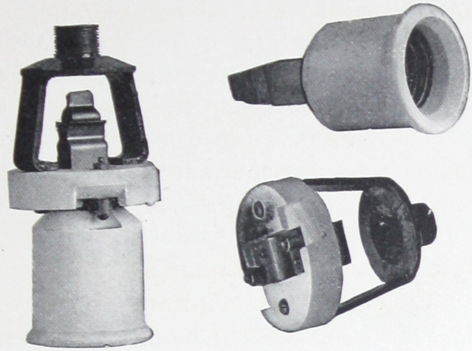
Total minimum losses, position of least reactance, cold, varied from 85 to 215 watts.

Total maximum losses, position of greatest reactance, hot, varied from 350 to 765 watts.

Heating coils minimum reactance varied from 30°C. to 55°C.—full load position.

Heating coils maximum reactance varied from 50°C. to 75°C.—full load position.

All these tests were made on 60 cycles, and, while it is very hard to make a comparative table covering all the



SOCKET AND RECEPTACLE

points on account of the fact that what one coil would gain on one feature it would lose on another, we endeavored to ascertain which coil would be the best for our use, and, after careful consideration, chose the General Electric Company's RD-140, and for the following reasons:

The mechanical construction, machine work, winding and insulation of the coils were best.

The minimum impedance was low.

The power factor was 98½%.

The regulation was better over its normal range.

The insulation was better for our purpose of placing coil out in the weather.

Now, having chosen the coil, we proceeded to place them on poles outside, and for this means we built small houses for the coils. The old 40 lamp circuits were cut over into 80 to 115 lamp circuits and placed on 2000 instead of 1000 volts, the system starting off all right.

You will note that I have said that we built little houses on the poles for the coils. We did this in order to

avoid returning one end of every circuit to the station; this method also saves considerable floor space. The operation is as follows:

From a system of mains at a point, say, three or four miles away, a circuit with its regulator is taken off, and the regulator is blocked to its full lamp load position, thereby preventing any abnormal increase in the current strength at starting. The current is then thrown on to these mains at a pressure below the normal and gradually increased until the ammeter shows the necessary full load current.

The results particularly noted of this change from the old 40 light method are:

A wonderful improvement in the street-light service as furnished the municipalities. Less complaint of dim light and circuits out.

A complete freedom from burning out a whole circuit on account of several lamps being out.

The maintenance of a constant current prevents straining of incandescent lamps, thus increasing their life.

A reduction in the labor necessary to care for the system.

Read before the meeting of the New England Association of Electrical Lighting Engineers.

CONSTANT CURRENT TRANSFORMERS FOR SERIES INCANDESCENT LIGHTING, 60 CYCLES

Kw.	Sec. Amp.	No. Circuits	Maximum Load Volts	NO. 3.5 WATT LAMPS ALLOWING 7.5% LINE LOSS				
				20 c.p.	25 c.p.	30 c.p.	40 c.p.	50 c.p.
4.4	1.75	1	2400	53	42	35	26	21
4.4	3.0	1	1400	53	42	35	26	21
4.4	3.5	1	1200	53	42	35	26	21
4.4	5.5	1	765	53	42	35	26	21
8.8	1.75	1	4850	107	86	71	53	43
8.8	3.0	1	2830	107	86	71	53	43
8.8	3.5	1	2425	107	86	71	53	43
8.8	5.5	1	1550	107	86	71	53	43
17.5	3.0	1	5700	216	174	144	108	87
17.5	3.5	1	4875	216	174	144	108	87
17.5	5.5	1	3120	216	174	144	108	87
24.5	3.5	2	6820	304	244	202	152	122
24.5	5.5	1	4340	304	244	202	152	122
35.0	5.5	2	6230	438	351	291	219	175

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